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Seawater–rock interaction-derived pyrites in altered oceanic crust regulate not only oceanic sulfur but also atmospheric oxygen

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Oceanic sulfur cycle is intimately linked to the cycles of organic matters and oxygen on the Earth's surface. However, controversy exists on the dominant pathway (pyrite vs. evaporite burial) of Phanerozoic oceanic sulfur cycle and its influence on atmospheric oxygen concentrations. This controversy arises from controversial pyrite burial flux (F_{py} = 2.40 vs. 31.5 × 10^{11} mol yr^{-1}), sparked by only counting sedimentary pyrites without seawater–rock interaction (SRI)-derived ones and by underestimating evaporite burial flux. To address these issues, we conduct in-situ sulfur isotopic analysis for SRI-derived pyrites from Hole U1502B in the South China Sea and calculate the burial flux (*FSRI PY*) of SRI-derived pyrites by employing a new equation without using evaporite burial flux. The studied pyrites exhibit positive δ^{34}S values (1.93–5.96‰), high contents of fluid-mobile elements (Pb of 5810–8870 ppm and Mo of 8260–10240 ppm) and temperature-sensitive elements (Co up to 1761 ppm and Cu up to 798 ppm), indicating a hydrothermal origin. The values of *F* SRI PY(7.23–14.9 × 10^{11} mol yr^{-1}), estimated from the S isotopic data of this study and compiled data for SRI-derived pyrites, are similar to the burial flux of sedimentary pyrite, highlighting the essential role of SRI in shaping the Phanerozoic oceanic sulfur cycle. The calculated high total F_{py} (1.40–2.91×10^{12} mol yr^{-1}) and pyrite burial fraction (f_{py} =47–97%), incorporating both sedimentary and SRI-derived pyrites, suggest that pyrite burial was the dominant pathway of Phanerozoic oceanic sulfur cycle, and actively regulated atmospheric oxygen concentrations (Miao et al., 2025). Moreover, the abrupt increases in Phanerozoic F_{py} and atmospheric oxygen concentrations were potentially associated with supercontinent assembly (Miao et al., 2025).